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(58) Field of Search
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INT CL^5 **F02B 23/00 23/08 23/10 29/02, F02M 35/10 61/14 69/46**

(54) **Fuel injected i.c. engine.**

(57) Fuel from the injector 20 is directed to pass through the orifice 16 opened by the poppet valve 14 when the latter is lifted off its seat, the fuel entering the combustion chamber directly without significantly impinging on the intake valve 14 nor on any wall of the intake port 12. At least during idle and part load conditions, the fuel injection is timed to take place only while the intake poppet valve 14 is open. The fuel may impinge on an ultrasonically vibrated shield (42, Figs. 3 and 4) carried by a spark plug (50). The injector outlet may be a tube (32, Fig. 2) with bends (34) which prevent air entry into the tube.

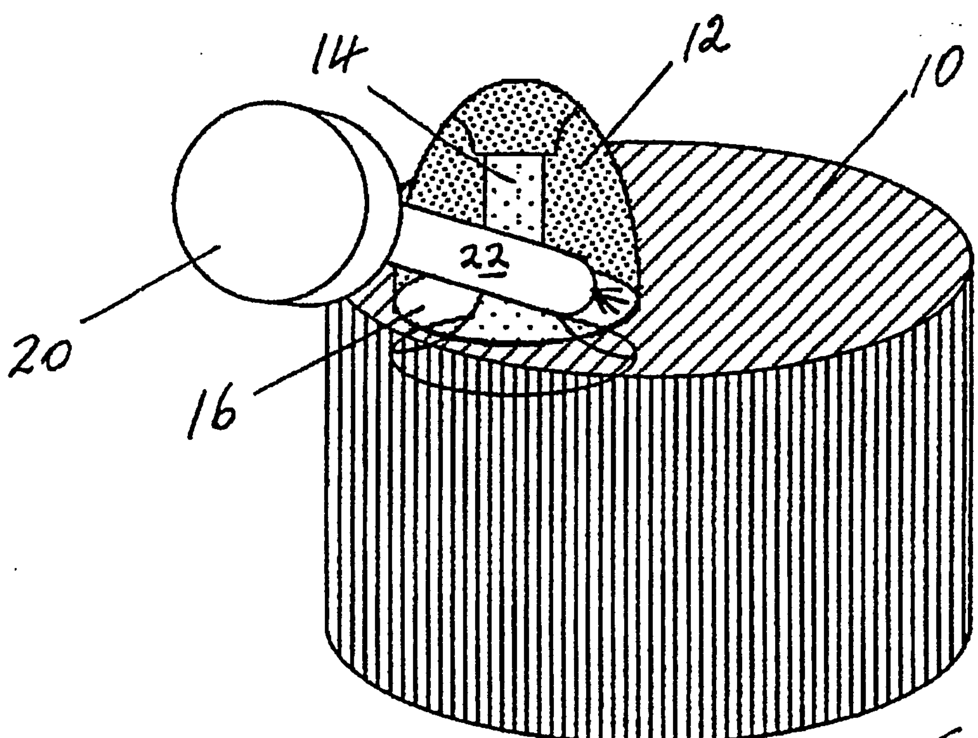

Fig 1

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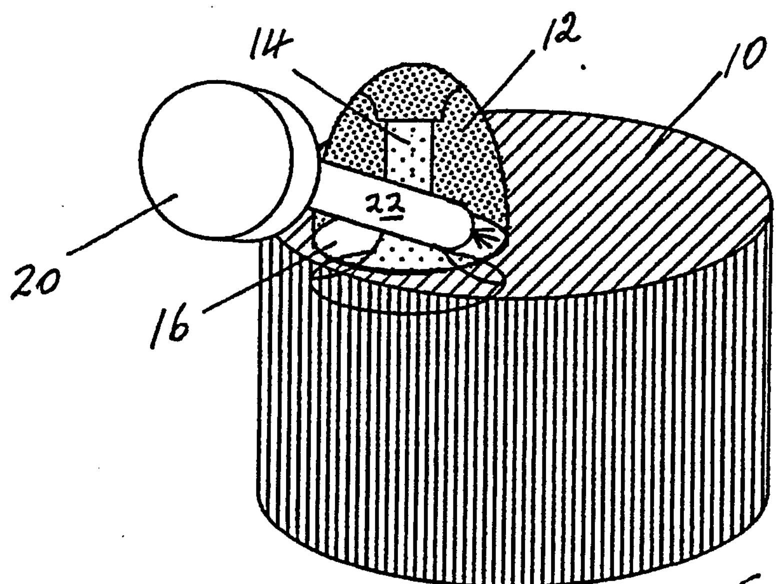


Fig. 1

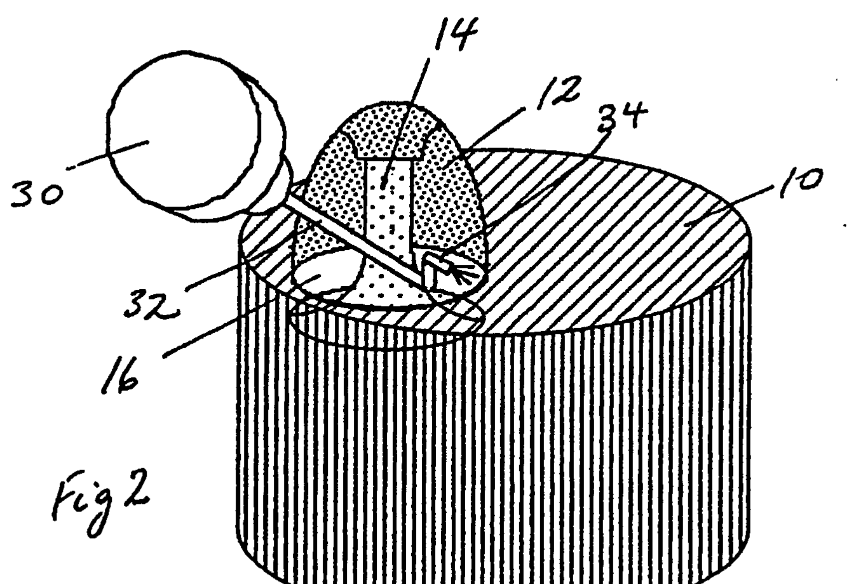


Fig 2

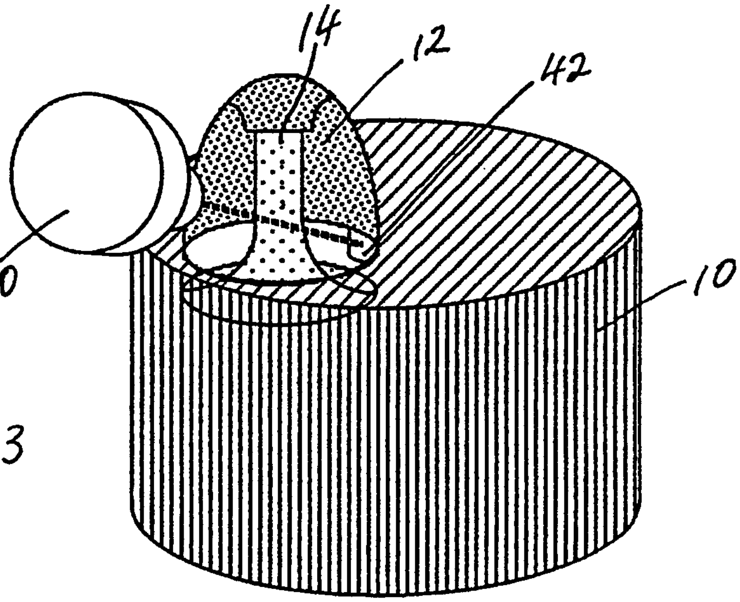
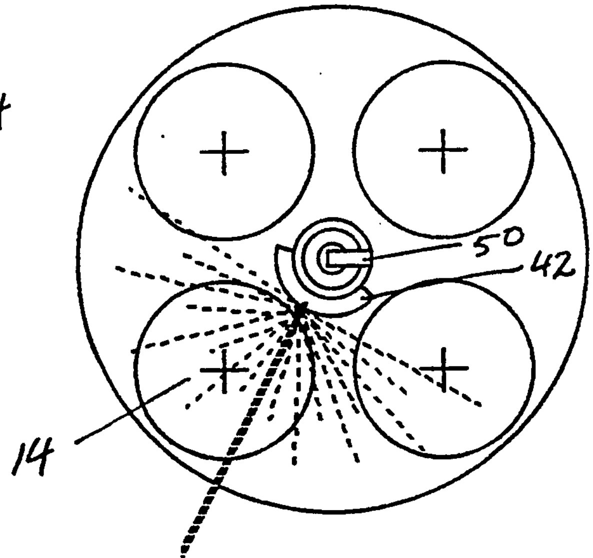


Fig 3

Fig 4



Fuel Injected Internal Combustion Engine

Field of the invention

The present invention relates to a fuel injected internal combustion engine.

Background of the invention

The advantage of fuel injection over a carburettor, as is well known, is that it avoids wetting of the intake manifold. Wall wetting creates a hysteresis effect whereby excess fuel needs to be introduced during acceleration phases and fuel evaporating from the walls of the manifold during deceleration phases causes undesirable hydrocarbon emissions. Cold starting is also a problem as most of the fuel introduced into the manifold only wets the manifold and little of it reaches the combustion chambers.

Conventional fuel injection systems that inject fuel into the intake port alleviate this problem but do not fully overcome it as there is still a lesser problem caused by wetting of the intake port. With the ever increasing requirements to reduce exhaust emissions, this problem can no longer be disregarded.

There have been proposals to provide in-cylinder injectors, normally termed direct injection as opposed to port injection. These injectors are necessarily costly as they have to withstand the severe conditions within the combustion chamber. They also provide less than ideal mixing of the fuel with the air which results in a stratified charge that is difficult to control.

Object of the invention

The present invention therefore seeks to provide an internal combustion engine with port injection in which the problems

associated with wall wetting of the intake port by the fuel spray from the injectors are mitigated.

Summary of the invention

According to the present invention, there is provided a port injected internal combustion engine in which each cylinder has as least one intake poppet valve and a fuel injector in the intake port leading to the poppet valve, wherein the fluid flow pattern from the injector is shaped and directed to pass through the orifice opened by the poppet valve when the latter is lifted off its seat, the fuel entering the combustion chamber directly without significantly impinging on the intake valve nor on any wall of the intake port and in which, at least during idle and part load conditions, the fuel injection is timed to take place only while the intake poppet valve is open.

In conventional port injection internal combustion engines, the injected fuel is finely atomised as soon as it leaves the injection nozzle located in the intake manifold close to the intake port to create a spray of which the centre line is directed to minimise wall wetting, the spray axis being generally in line with the centre of the intake valve. The intention is for the atomised fuel to have minimum contact with the walls of the intake port and to be carried along by the intake air flow, but because a sufficiently small droplet size for this to occur cannot be achieved easily, the normal result is for the spray to hit all the walls of the intake port and line them with fuel.

By contrast, in the present invention, the fuel is intentionally directed away from the intake poppet valve and aimed at the orifice opened by the poppet valve when it is lifted off its seat. This delivers fuel directly into the combustion chamber and gives the same advantages as in-cylinder direct injection while using an injector that is protected from the severe conditions within the combustion

chamber by the intake poppet valve. The fuel is admitted at the same time and through the same opening as the intake air and unlike direct injection the resulting charge can be homogeneous with the fuel well mixed with the air.

To avoid wall wetting in the intake port, it is necessary that the width of the fluid flow pattern from the injector to have a narrow width at the intake valve orifice to avoid the fuel landing on the intake port and the intake valve.

Several possibilities exist for designing the injectors to avoid such wall wetting at the intake port while still placing the injector in the intake manifold where it can operate at a relatively cool temperature.

If one looks down an intake port while the intake valve is open, there already exists in many engines a line of sight that permits the combustion chamber to be viewed through the orifice of the opened valve. In other engines such a line of sight passage can be created by drilling or minor modification to the shape of the intake port. In such engines, it is possible to aim a fine coherent jet of fuel along this line of sight directly into the combustion chamber. Within the combustion chamber, the jet may be aimed at a target in order for the fuel to be atomised within the combustion chamber. This target may be vibrated ultrasonically to enhance fuel atomisation.

Alternatively, the injector may be designed with a long nozzle passing along the line of sight and terminating very close to the intake valve. In this case, the injector produces a spray which diverges not from the intake manifold but from near the intake valve so that when passing through the gap between the poppet valve and its valve seat the diverging spray is still sufficiently narrow to avoid contact with the walls of the intake port and the poppet valve. Minor over spray on to the intake valve in this case may occur but in view of the temperature of the valve and

the air flow conditions at the valve opening, the fuel cannot settle and the valve will still be essentially dry when it is closed.

The injector may in this case be of conventional design except for the lengthening of the pintle normally used to open and close the fuel exit orifice at the tip of the injection nozzle. The nozzle may furthermore be surrounded by an air shroud if an air assisted spray is required.

The injector may also be an air blast injector where pressurised air is used to force the fuel out of the injector. In all these cases, the fuel is finely atomised and delivered directly into the combustion chamber without suffering any corruption of the spray quality by impingement upon the walls of the intake port.

When there is no line of sight from the intake manifold into the combustion chamber, it is possible to use a hollow feed tube to supply the fuel from a conventional injector to a point in close proximity to the intake valve. Such a feed tube may incorporate a U-bend or an S-bend to prevent air from rising along the tube towards the injector so as to ensure that the feed tube remains full of fuel under all conditions.

The shape of the fuel spray need not be conical and may instead be a flat jet produced by a slit orifice or by a row of small holes in order to make full use of the narrow annular gap opened by the intake valve.

Brief description of the drawings

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view looking through the intake port of an internal combustion engine into a combustion chamber and illustrating a first embodiment of the invention,

Figures 2 and 3 are views similar to Figure 1 showing two further embodiments of the invention, and

Figure 4 is a schematic plan view from below of the cylinder head of the embodiment represented in Figure 3.

Description of the preferred embodiments

In Figure 1, a combustion chamber 10 is represented by an upright cylinder with striped shading. The intake port 12 is shown with speckled shading and the intake valve 14 is illustrated in its open position, in which an orifice 16 for admitting the charge into the combustion chamber is present between the valve skirt and the valve seat in the cylinder head. The visibility of the orifice 16 from the intake port indicates that there is an unobstructed rectilinear path from the intake manifold to the intake orifice 16 and in Figure 1 the fuel is arranged to flow along this path so as to enter the combustion chamber 10 directly without coming into contact with the walls of the intake port 12 or the valve 14.

This is achieved in Figure 1 by a special design of the injector 20 arranged in the intake manifold. The injector has a long nose 22 that passes to one side of the valve stem and its end includes an injection nozzle positioned to direct its spray through the orifice 16. Because the nose is straight, a pintle operated by a solenoid can pass along the length of the nose in a conventional manner to open and close the injection nozzl . Because the injector, apart from the length of the nose 22, can be conventional, it may benefit from other known features of injector design such as an air assisted spray. An air shroud may surround the nose

22 and assist in atomising the fuel in the spray, the air being drawn either from ambient air or from a point further upstream in the intake manifold. As a further alternative, an air blast injector may be used, in which pressurised air is used to force fuel out of the injector.

In Figure 2, a conventional injector 30 is used and the only modification is to add a feed tube 32 for guiding the fuel metered by the injector towards the orifice 16. The tube 32 is merely a hollow tube in this embodiment that contains no moving parts. To prevent air entry into the feed tube, a double bend 34 is formed at its end. By preventing air from rising along the feed tube, this design ensures that the column of fuel in the feed tube 32 always remains constant and does not therefore affect the quantity of fuel reaching the combustion chamber.

In both the previous embodiments, the injector is designed to produce a spray or flat jet at its nozzle and wall wetting is avoided by moving the spray nearer to the orifice 16. In the embodiment of Figure 3, instead of producing an atomised spray, the injector 40 produces a fine jet that is aimed through the orifice 16 at a target 42 within the combustion chamber. The fuel is broken up into fine droplets within the combustion chamber by impact with the target 42. If desired, ultrasonic vibrations may be applied to the target 42 to assist in fuel atomisation. The target 42, as shown in Figure 4, can be constructed as a semicircular shield surrounding the spark plug 50 to prevent wetting of the electrodes by the fuel jet. Furthermore, such positioning of the target avoids obstruction to the entry of the intake air and emulates a centrally positioned in-cylinder direct injector even though fuel is introduced through only one of the two intake ports.

In all the embodiments described, the air and fuel enter the combustion chamber at the same time and through the same opening since the fuel is only injected while the intake

valve is open. By suitable design of the ports and combustion chamber one can ensure that the turbulence, swirl and torroidal flow patterns in the intake air result in thorough mixing of the fuel in the intake charge. Alternatively, by designing the combustion chamber to promote localised mixing and by timing the injection to concentrate the fuel in the vicinity of the spark plug it is possible to create a stratified charge.

A well optimised stratified charge engine will be capable of very lean burn and throttleless load control where the engine power can be adjusted by setting the fuel quantity directly, without relying exclusively on throttling to vary the air charge density.

Features from the embodiments of Figures 2 and 3 may be combined to enable a fuel jet to be aimed at the orifice 16 from a point within the intake port even when there is no line of sight from the manifold to the combustion chamber. Furthermore, even when the fuel is delivered from the injector in the form of a spray, it may be directed at a target in the combustion chamber to assist in its further atomisation.

To gain the advantage of a dry intake port, it is necessary to time the injection to occur while an intake valve is open. This places constraints on the design of the injector in that the latter is required to have a dynamic range that permits fine control of small metered quantities for idling and part load conditions while being able to supply a large amount of fuel at full load in the relatively short duration of the intake valve event.

One may meet these requirements by using two injectors or dual pressure injectors but a less costly alternative is to suffer a small degradation of performance by allowing some wall wetting under full load conditions. The invention will still result in a reduction in hydrocarbon emissions by

limiting the extent of the wall wetting and under most conditions the small proportion of the fuel sprayed into the intake port when the valve is closed will evaporate and be drawn into the combustion chamber in the following cycle.

Because of the fact that in the present invention substantially all the fuel delivered by an injector during an engine cycle enters the combustible charge during that same cycle, all the problems associated with hysteresis are circumvented. The control system for the fuel injectors may therefore be considerably simplified, no additional steps being necessary to compensate for fuelling errors during cold start, cold running, acceleration and deceleration.

This saves development time and calibration effort and reduces the work load demand on the engine control electronics since currently 80% of vehicle calibration is related to cold start, cold running and transient fuel control to ensure satisfactory drivability.

CLAIMS

1. A port injected internal combustion engine in which each cylinder has as least one intake poppet valve and a fuel injector in the intake port leading to the poppet valve, wherein the fluid flow pattern from the injector is shaped and directed to pass through the orifice opened by the poppet valve when the latter is lifted off its seat, the fuel entering the combustion chamber directly without significantly impinging on the intake valve nor on any wall of the intake port and in which, at least during idle and part load conditions, the fuel injection is timed to take place only while the intake poppet valve is open.

2. An engine as claimed in claim 1, wherein each fuel injector is designed to aim a fuel jet or spray through the orifice of the open intake valve at a target located within the combustion chamber.

3. An engine as claimed in claim 2, wherein means are provided for applying ultrasonic vibrations to the target.

4. An engine as claimed in claim 1, wherein the injector has a hollow feed tube leading from the injection nozzle to a point in close proximity to the orifice opened by the poppet valve.

5. An engine as claimed in claim 4, wherein a bend is formed in the feed tube to prevent air from rising along the feed tube.

6. An engine as claimed in claim 1, wherein the injector has a long nose terminating in a nozzle located in close proximity to the orifice opened by the poppet valve, the nozzle being opened and closed by a pintle extending along the length of the nose.

7. An engine as claimed in claim 6, wherein an air shroud is provided around the nose to provide air for assisting in the atomisation of the fuel discharged from the nozzle.

8. An engine as claimed in claim 1, wherein the injector is an air blast injector, in which pressurised air is used to force the fuel out of the injector.

9. An engine as claimed in any preceding claim, wherein the fuel injector is operative to produce a flat spray.

10. An engine as claimed in any preceding claim, wherein the fuel injection is timed to commence at an early stage in opening of the intake valve so as to promote homogeneous mixing.

11. An engine as claimed in any one of claims 1 to 9, wherein fuel injection is timed to commence at a late stage in the opening of the intake valve so as to promote charge stratification.

12. An engine as claimed in claim 11, wherein the engine output power is regulated by varying the quantity of fuel injected so as to place less reliance on throttling to vary the air charge density.

13. An engine constructed, arranged and adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9302057.6

Relevant Technical fields (i) UK Cl (Edition L) F1B (ii) Int Cl (Edition 5) F02B 23/00 23/08 23/10 29/02 F02M 35/10 61/14 69/46	Search Examiner R J DENNIS
Databases (see over) (i) UK Patent Office (ii)	Date of Search 5 APRIL 1993

Documents considered relevant following a search in respect of claims 1 TO 13

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
X	GB 1456153	(NIPPON) see particularly lines 4 to 7, page 4 and Figures 8 and 9	1, 2, 4 and 5
X	GB 1092736	(FORD) see particularly Figure 3	1, 2 and 12
X	GB 1028608	(FORD) see particularly Figures 10 and 11	1, 2, 11 and 12
X	GB 0735230	(USTAV) see particularly lines 66 to 2, page 2	1 and 2
X	GB 0299117	(GROVES) see particularly Figure 3	1

to claim(s)

Categ ries of documents

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